CLAIMS:

1. A quad compensated ensemble crystal oscillator system for use in a well borehole system comprising an ensemble of quad compensated clocks, each said quad compensated clock comprising four oscillator crystals; wherein for each said quad compensated clock:

(a) said oscillator crystals in each said quad compensated clock are configured relative to a sensitivity vector of each said oscillator crystal to form a quad compensated resonator;

(b) outputs of said oscillator crystals in said quad compensated resonator are combined to form a quad compensated clock output; and

(c) said configuration and said combination of said outputs of said oscillator crystals are selected to reduce effects of acceleration upon said quad compensated clock output.

2. The system of claim 1 further comprising:

(a) an ensemble of four said quad compensated clocks; and

(b) a processor having software resident therein, wherein said processor is operationally connected to said quad compensated clocks; wherein

(c) each said quad compensated clock output from each said quad compensated clock is combined within said processor using said software to yield an quad compensated ensemble crystal oscillator clock output exhibiting less frequency drift as a function of time than any one said quad compensated clock in said ensemble.

3. The system of claim 2 further comprising a quad compensated temperature sensor, wherein output of said quad compensated temperature sensor is combined with said quad compensated clock outputs within said processor and using said software to minimize effects of temperature upon said quad compensated ensemble crystal oscillator clock output.

4. The system of claim 3 wherein said software comprises:

(a) an optimization algorithm which is used to process each said quad compensated clock output; and

(b) a time-scale algorithm which is used to process two or more said quad compensated clock outputs from said ensemble.

5. The system of claim 4 wherein said optimization algorithm detects and corrects each said quad compensated clock output for:

(a) aging;

(b) hysteresis;

(c) crystal warm-up; and

(d) short-term and long-term frequency stability characteristics, considering statistical independence of said quad compensated clocks.

6. The system of claim 4 wherein said time-scale algorithm:

(a) assures that three or more said quad compensated clocks of said ensemble provide statistical separation capability;

(b) provides means for calculating a time difference between any two said quad compensated clocks in said ensemble using time differences taken simultaneously between adjacent said quad compensated clocks;

(c) provides stochastic performance parameters which allow optimum estimate of time, frequency, relative frequency drift, and a weighting factor for each of the said quad compensated clocks in said ensemble;

(d) provides de-weighting of that clock so that the quad compensated ensemble crystal oscillator system output is not degraded;

(e) uses a time error-temperature change correlation measured by said quad compensated temperature sensor to upgrade a temperature profile model resident within said time-scale algorithm;

(f) based upon operational environment changes sensed by one or more external environmental sensors, adaptively changes appropriate algorithms within said time-scale software; and

(g) provides said quad compensated ensemble crystal oscillator clock output.

7. The system of claim 6 wherein said quad compensated ensemble crystal oscillator clock output is frequency stable to less than about 3 x 10^{-9} and over a temperature range of 0 to 185 degrees Centigrade.

8. The system of claim 3 wherein said system is calibrated to a reference frequency.

9. The system of claim 2 wherein said quad compensated resonator comprises oscillator crystals having a temperature stability of about ±20 parts per million over a temperature range of about 0 to 180 degrees Centigrade.

10. The system of claim 3 wherein said quad compensated temperature sensor comprises oscillator crystals having a temperature stability of about ±4500 parts per million over a temperature range of about 0 to 180 degrees Centigrade.

11. A quad compensated clock for use in a borehole system, said quad compensated clock comprising:

(a) a quad compensated resonator comprising four oscillator crystals

(i) electrically connected in series with their acceleration sensitivity vectors aligned, nominally one per quadrant, in a common plane, and

(ii) configured in pairs so that maximum acceleration sensitivity vectors of oscillators comprising said pairs are in opposite directions; and

(b) oscillator circuitry cooperating with said quad compensated resonator; wherein

(c) outputs of said oscillator crystals in said quad compensated resonator are combined and input to said oscillator circuitry to form a quad compensated clock output with reduced sensitivity to acceleration.

12. The clock of claim 11 wherein said quad compensated resonator comprises oscillator crystals having a temperature stability of about ±20 parts per million over a temperature range of about 0 to 180 degrees Centigrade.

13. The clock of claim 11 wherein said quad compensated clock output is corrected, using a compensation algorithm resident in a processor cooperating with said clock, for:

(a) crystal aging;

(b) crystal hysteresis;

(c) crystal warm-up; and

(d) crystal short-term and long-term frequency stability characteristics.

14. The clock of claim 11 further comprising packaging for said quad compensated resonator and said cooperating oscillator circuitry, wherein said packaging comprises insulation to reduce sharp temperature fluctuations and thermal transient effects in said quad compensated resonator and said cooperating oscillator circuitry.

15. A system for measuring a parameter of earth formation in the vicinity of a borehole, the system comprising:

(a) a borehole assembly comprising

(i) a quad compensated ensemble crystal oscillator system comprising an ensemble of quad compensated clocks, each said quad compensated clock comprising four oscillator crystals, wherein for each said quad compensated clock,

said oscillator crystals in each said quad compensated clock are configured relative to a sensitivity vector of each said oscillator crystal to form a quad compensated resonator,

outputs of said oscillator crystals in said quad compensated resonator are combined to form a quad compensated clock output for each quad compensated clock, and

(ii) a geophysical sensor;

(b) a conveyance structure for conveying said borehole assembly along said borehole;

(c) means for combining said quad compensated clock outputs to form a quad compensated ensemble crystal oscillator clock output, and

(d) means for combining output from said geophysical sensor with said quad compensated ensemble crystal oscillator clock output to determine said parameter of earth formation.

16. The system of claim 15 further comprising a well site reference to which said quad compensated ensemble crystal oscillator system is calibrated.

17. The system of claim 15 wherein said conveyance structure comprises a tubular.

18. The system of claim 15 wherein said tubular comprises a drill string.

19. The system of claim 15 wherein said conveyance structure comprises a cable.

20. The system of claim 15 wherein said system is a seismic-while-drilling system.

21. The system of claim 15 wherein said system is a nuclear logging-while-drilling system.

22. A method for measuring time from within a borehole system, the method comprising;

(a) providing an ensemble of quad compensated clocks, each said quad compensated clock comprising four oscillator crystals;

(b) configuring said oscillator crystals in each said quad compensated clock to a sensitivity vector of each said oscillator crystal to form a quad compensated resonator;

(c) combining outputs of said oscillator crystals in said quad compensated resonator to form a quad compensated clock output; and

(c) selecting said configuration and said combination of outputs of said oscillator crystals to reduce effects of acceleration upon said quad compensated clock output.

23. The method of claim 22 further comprising:

(a) providing an ensemble of four said quad compensated clocks; and

(b) combining each said quad compensated clock output from each said quad compensated clock to yield an quad compensated ensemble crystal oscillator clock output exhibiting less frequency drift as a function of time than any one said quad compensated clock in said ensemble.

24. The method of claim 23 further comprising:

(a) providing a quad compensated temperature sensor; and

(b) combining output of said quad compensated temperature sensor with said quad compensated clock outputs to minimize effects of temperature upon said quad compensated ensemble crystal oscillator clock output.

25. The method of claim 24 further comprising:

(a) processing each said quad compensated clock output with an optimization algorithm; and

(b) processing two or more said quad compensated clock outputs from said ensemble with a time-scale algorithm.

26. The method of claim 25 further comprising correcting, using said optimization algorithm, each said quad compensated clock output for effects of:

(a) aging;

(b) hysteresis;

(c) crystal warm-up; and

(d) short-term and long-term frequency stability characteristics, considering statistical independence of said quad compensated clocks.

27. The method of claim 25 further comprising, using said time-scale algorithm:

(a) assuring that three or more said quad compensated clocks of said ensemble provide statistical separation capability;

(b) providing means for calculating a time difference between any two said quad compensated clocks in said ensemble using time differences taken simultaneously between adjacent said quad compensated clocks;

(c) providing stochastic performance parameters which allow optimum estimate of time, frequency, relative frequency drift, and a weighting factor for each of the said quad compensated clocks in said ensemble;

(d) de-weighting of that clock so that the quad compensated ensemble crystal oscillator system output is not degraded;

(e) using a time error – temperature change correlation to upgrade a temperature profile model resident within said time-scale algorithm;

(f) adaptively changing appropriate algorithms within said time-scale software; and

(g) providing said quad compensated ensemble crystal oscillator clock output

28. The method of claim 27 wherein said quad compensated ensemble crystal oscillator clock output is frequency stable to less than about 3 x 10^{-9} and over a temperature range of 0 to 185 degrees Centigrade.

29. The method of claim 24 further comprising calibrating said system to a reference frequency.

30. The method of claim 23 wherein said quad compensated resonator comprises oscillator crystals having a temperature stability of about ±20 parts per million over a temperature range of about 0 to 180 degrees Centigrade.

31. The method of claim 24 wherein said quad compensated temperature sensor comprises oscillator crystals having a temperature stability of about ±4500 parts per million over a temperature range of about 0 to 180 degrees Centigrade.

32. A method for measuring time from within a borehole system using a quad compensated clock, said method comprising:

(a) forming a quad compensated resonator by

(i) providing four oscillator crystals,

(ii) electrically connecting said four oscillator crystals in series with their acceleration sensitivity vectors aligned, nominally one per quadrant, in a common plane, and

(iii) configuring said crystal oscillators in pairs so that maximum acceleration sensitivity vectors of oscillators comprising said pairs are in opposite directions;

(b) providing oscillator circuitry cooperating with said quad compensated resonator;

(c) providing said measure of time by combining outputs of said oscillator crystals in said quad compensated resonator and inputting to said oscillator circuitry to form a quad compensated clock output with reduced sensitivity to acceleration.

33. The method of claim 32 wherein said quad compensated resonator comprises oscillator crystals having a temperature stability of about ±20 parts per million over a temperature range of about 0 to 180 degrees Centigrade.

34. The method of claim 32 further comprising correcting said quad compensated clock output, using a compensation algorithm, for:

(a) crystal aging;

(b) crystal hysteresis;

(c) crystal warm-up; and

(d) crystal short-term and long-term frequency stability characteristics.

35. The method of claim 32 further comprising disposing said quad compensated resonator and said cooperating oscillator circuitry within packaging which is insulated to reduce sharp temperature fluctuations and thermal transient effects in said quad compensated resonator and in said cooperating oscillator circuitry.

36. A method for measuring a parameter of earth formation in the vicinity of a borehole, the method comprising:

(a) providing a borehole assembly comprising

(i) a quad compensated ensemble crystal oscillator system comprising an ensemble of quad compensated clocks, each said quad compensated clock comprising four oscillator crystals; wherein for each said quad compensated clock,

said oscillator crystals in each said quad compensated clock are configured relative to a sensitivity vector of each said oscillator crystal to form a quad compensated resonator, and

outputs of said oscillator crystals in said quad compensated resonator are combined to form a quad compensated clock output, and

(ii) a geophysical sensor;

(b) conveying said borehole assembly along said borehole by means of a conveyance structure;

(c) combining said quad compensated clock outputs to form a quad compensated ensemble crystal oscillator clock output; and

(d) combining output from said geophysical sensor with said quad compensated ensemble crystal oscillator clock output to determine said parameter of earth formation.

37. The method of claim 36 further comprising calibrating said quad compensated ensemble crystal oscillator system to a well site reference.

38. The method of claim 36 wherein said conveyance structure comprises a tubular.

39. The method of claim 36 wherein said tubular comprises a drill string.

40. The method of claim 36 wherein said conveyance structure comprises a cable.

41. The method of claim 36 wherein said system is a seismic-while-drilling system.

42. The method of claim 36 wherein said system is a nuclear logging-while-drilling system.